United States Department of Agriculture
Bureau of Entomology and Plant Quarantine

A MECHANICAL TRAP FOR THE SAMPLING OF AERIAL INSECT POPULATIONS[1]

By Joseph C. Chamberlin and F. R. Lawson, Division of Truck Crop and Garden Insect Investigations[2]

The trap described herein was developed in its original form during July 1935 in the course of investigations on the flight habits and dispersal of the beet leafhopper (Eutettix tenellus (Bak.)). It was devised to meet a need for quantitatively sampling the numbers of leafhoppers actually in flight. The trap has been employed principally in studies of the flight habits and dispersal of the beet leafhopper and the pea weevil (Bruchus pisorum (L.)).

The essential principle involved in the construction of all models of this trap is that power is so applied to one or more rigid insect nets as to cause them to rotate in a fixed horizontal plane at a speed sufficient to capture and concentrate in a removable collecting bag any insects which might be intercepted.

A trap using essentially this same principle was independently developed by Williams and Milne[3] and Davies[4] and described under date of December 1935. The Williams and Milne trap used

---

[1] A brief, popular description (apparently a news reporter's account) of this trap appeared under the heading "Patents, Processes, Inventions" on page 96 of the August 1939 issue of Science Digest, Vol. 6, No. 2. See also: Cody, Chas. E. Rotary Trap Aids in Collecting Field Data on Insects. Market Growers Journal (Louisville, Ky.) 65 (12): 512, illus. (Dec. 15, 1939.)

[2] The writers are indebted to George T. York, of the Division of Truck Crop and Garden Insect Investigations, who helped design and build the trap shown in figure 5, and to Alfred A. Barney, of the same division, for suggestions and help with the mechanical details of several models.

[3] Williams, C. B., and Milne, P. A. A Mechanical Insect Trap. Bul. Ent. Res. 26 (4): 543-552, illus. 1935.

[4] Davies, W. Maldwyn. A Water-Power Mechanical Insect Trap. Bul. Ent. Res. 26 (4): 553-558, illus. 1935.

electric fans mounted in the nets for propulsion; the Davies adaptation of the same trap used a water wheel for power in much the same fashion that we employed an electric or gasoline motor. Williams and Milne and Davies used open-mesh cloth for nets, while we used 16-mesh wire screen, which we found much more efficient as well as more durable. Both the above papers mention difficulties caused by insects remaining in the net. We have not had this trouble, all insects caught being blown into the small collecting bag. This may be due to the speed of net rotation. Williams and Milne used a speed of only four and one-half and Davies used five revolutions per minute. The speeds employed by us ranged from 50 to 67 r. p. m. The length of the net arms was about the same for the two types of traps. The comparatively high speed adopted by us also prevented insects from dodging the moving nets and from crawling or flying out of the net after being caught. Neither Williams and Milne nor Davies mention any such difficulty, but, as they were working with aphids, it would not be expected that this would be a factor. Those authors had trouble keeping the speed of rotation constant in variable winds. No difference in speed could be noted in our traps in winds from 0 to 20 miles per hour when the net speed was set for a minimum of 55 to 60 r. p. m. The estimated cost of the Williams and Milne trap is about the same as of the one here described.

A trap built upon the plan here presented will efficiently sample aerial insect populations, with the possible exception of certain swiftly flying Odonata, Diptera, etc. It offers a quantitative method of determining the density of insects at different elevations and at different periods of the diurnal and annual cycles relative to such factors as time, temperature, humidity, light intensity, and so on. Accurate records can be obtained for periods as brief as 5 minutes or less or for as much longer as desired. If the interval between the taking of collections is not too long, the insects caught are generally not seriously damaged and are for the most part in suitable condition for preservation as museum specimens.

An excellent illustration of the type of data which can be obtained with this machine is contained in a paper by Barnes, Fisher, and Kaloostian,[5] who used one of the machines built by the present writers. Each net of this trap (net opening, 2 square feet in area; diameter of circle described by net, 12 feet) will theoretically collect the insects from approximately 248,000 cubic feet of air per hour at a speed of 55 r. p. m.

---

[5] Barnes, Dwight F., Fisher, Charles K., and Kaloostian, George H. Flight Habits of the Raisin Moth and Other Insects as Indicated by the Use of a Rotary Net. Jour. Econ. Ent. 32 (6): 859-863, illus. 1939.

The cost of the machine, exclusive of the motor, will range from \$50 to \$70 if built by hired labor. The machine can be built by any good automobile mechanic or machinist.

The writers have collectively and individually been responsible for the building of six different traps. All were alike in essential features. Probably the best trap, mechanically, was one of those constructed by the senior author at Corvallis, Oregon, for use in studies of pea weevil flight. This model will be described in some detail, with references to other models. It is obvious that great variation in structural detail is possible within the broad limits imposed by the required performance.

The essential mechanical features of the trap are illustrated in the accompanying illustrations (figs. 1 to 7).

The net assembly comprises one or more nets, together with supporting radial arms and adjustments. Where only one net is employed, it must be suitably counterbalanced. Each net is mounted at the end of a braced, 6-foot arm, so that in rotation the nets describe a circle 12 feet in diameter. The entire net assembly may be either heavy bolted wooden construction, as shown in figure 1, or more lightly made of $1\frac{1}{2}$-inch welded angle iron, as in the model shown in figure 2.

Since the speed of the motor is much greater than that of the net, and the axis of rotation of the motor is in a horizontal plane while that of the nets is in a vertical plane, it is necessary that there be an intervening set of gears. In the traps illustrated, a cutdown rear axle of a model T Ford car, mounted L fashion on the net support, serves this purpose. Any automobile rear axle should be equally adaptable. One axle is cut off just beyond the differential housing, and a plate is then welded across the casing to make it oil-tight. The hub of one of the wheels of the rear axle assembly is then employed for mounting the net arms, while the universal transmission joint of the drive shaft serves the same purpose in the trap as in the original automobile. Because of the light load, a light crankcase motor oil replaces the usual heavy lubricant in the differential. The whole unit is very durable and weatherproof.

The machine is driven by a transmission shaft extending from the net drive shaft to the motor and clutch assembly, which is mounted beyond the sweep of the rotating nets. A flexible connection should be used to connect the motor or drive shaft and the transmission shaft.

The motor and clutch assembly (figs. 3 and 4) comprises a small gasoline or electric motor. We have employed $\frac{1}{2}$ to 1 horsepower gasoline motors and $\frac{1}{4}$ to $\frac{1}{2}$ horsepower electric motors with

complete satisfaction. Where electric power is available its use is preferable, since electric motors require less attention and are more reliable than gasoline motors. If a single-phase electric motor is employed, the use of a clutch is unnecessary, as the trap can be started and stopped by turning a switch. With split-phase motors the clutch must be used to avoid throwing too heavy a starting load on the motor. One net is about the maximum load for a $\frac{1}{4}$-horsepower motor. We have used a $\frac{1}{3}$-horsepower motor to pull two nets. The power required depends somewhat upon the efficiency of the gears employed.

If the automobile transmission is used, one or more reduction pulleys or gears between the motor and clutch are necessary in order to achieve the required net speed. The exact nature and size of these reduction pulleys or gears will vary with the normal motor speed and the desired speed of rotation. Where belt transmission is used, slippage must be allowed for if a particular net speed is desired.

Two distinct but equally satisfactory motor and clutch assemblies are shown in figures 3 and 4. Others equally satisfactory from a mechanical standpoint can no doubt be improvised by any good mechanic. The use of a small manufactured clutch assembly, such as is used in machine and woodworking shops (fig. 3), is probably the most satisfactory arrangement in the long run, although the homemade assembly shown in figure 4 has proved fairly satisfactory. In this later assembly the machine is started gradually and stopped by tightening and loosening the belt between the motor and clutch assembly by means of a screw made from an automobile jack.

In the first model of the trap which was built a worm gear from a washing machine provided the gear reduction. This was satisfactory as long as the load was limited to one small net. In some models the reduction in speed from the motor to the trap was obtained by a series of belts and countershafts. This arrangement is cheap and is easier for amateur mechanics to build, but is not so satisfactory as a reliable set of gears. The belts must be protected from the rain.

One of the belt-driven models is shown in figure 5. This particular model was designed to study the height of flight of the beet leafhopper. The frame was of wood, bolted together and held in place by guy wires. The height of the nets was $2\frac{1}{2}$, 15, and 32 feet above the ground. The center shaft was made of 1-inch iron pipe hung from a large thrust bearing at the top to prevent kinking.

The details of the net construction are shown in figure 6. An adjustable method of mounting the nets on the net arms is shown in figure 8. The framework of the net is of $\frac{1}{4}$-inch iron rod and is welded throughout. The net proper is of 16-mesh wire screen.

Two types of collecting bags have been used. One is shown in detail in figure 9. The fine copper-guaze bottom prevents serious injury or destruction of the trapped insects. If all-cloth (muslin or similar material) bags are employed, the use of a small wire frame to keep the bag permanently distended minimizes injury to the trapped insects. If such a frame is not used, strong eddies in combination with a marked whipping of the bag badly damage the insects caught.

At the end of each collecting period the small collecting bags are removed and immediately replaced by new bags. The insects collected in the small bags are killed by dropping the bag into a large-mouthed killing jar and are later sorted and counted.

The dimensions of the net, the length of the net arm, and the speed of rotation are optional. The only essential points to be considered are that the taper of the net be sufficient to prevent the escape of small insects and that the speed be great enough to prevent large insects from dodging the net or escaping after being caught. The writers have considered that a large-meshed screen with a long taper was more efficient than a fine screen with a short taper. The long-tapered nets direct even very small insects into the collecting bag without loss or serious injury, whereas a net with a short taper would result in loss through the mesh or crushing and sticking on the screen. The long-tapered net with wider mesh allows more air to pass through than a short-tapered net with narrow mesh, and thus increases efficiency.

A net speed of 20 to 25 miles per hour is adequate to retain most insects. Even at this speed, however, strong insects may escape, not by flying out of the net but by crawling out of it. The loss from this source is probably unimportant for short runs, although with runs as long as an hour or more it might be serious with some species. On the other hand, with aphids or similar passive flyers a speed as low as 4 to 5 r. p. m. would be satisfactory, as proved by Williams and Milne and by Davies (loc. cit.). The attainment of a given net speed is obviously dependent upon the number of revolutions per minute of the net arms and the length of the net arms. The smaller the circle described by the nets, the faster the speed of rotation required to provide a given net speed. The writers preferred a relatively large circle of revolution in order to avoid such things as "flicker" which might possibly prove attractive or repellent to certain insects. With 6-foot net arms, such as were used in the traps illustrated, a net speed of 55 r. p. m. is equivalent to 23 to 24 miles per hour.

If it is desirable to sample insect aerial populations over an extended area rather than in one spot, a net like the ones used

on the rotary traps can be mounted on an automobile.[6] When the car is in motion, insects are collected in exactly the same manner as by the rotary trap. Such a mount is shown in figure 8. It is important that the net be mounted at least 1 foot away from the fender or hood of the car to avoid strong eddies which tend to force insects through the mesh of the screen. The writers have used car speeds up to 45 miles per hour. This apparatus has proved very useful under certain circumstances and can be built very cheaply.

---

[6] The use of a net on an automobile for the collection of insects in flight was apparently first employed by A. Bonnet in 1911. (Recherches sur les causes des variations de la faunule entomologique aerienne. Compt. Rend. Acad. Sci. (Paris) 152: 336-339. 1911.) See also: McClure, H. Elliott. Insect Aerial Populations. Ann. Ent. Soc. Amer. 31 (4): 504-513, illus. 1938.

Figure 1.--General view of rotary trap. Corvallis, model A. (Photograph by K. W. Gray.)

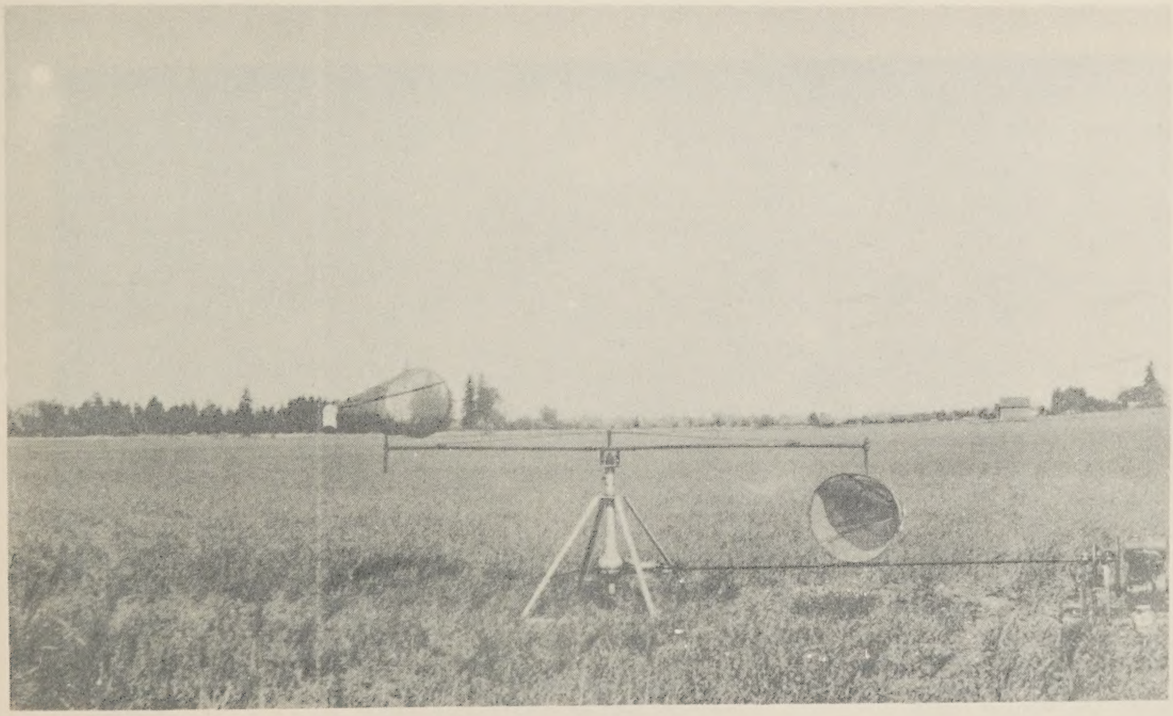

Figure 2.--General view of rotary trap. Corvallis, model B. Note the pyramidal frame of welded angle iron instead of the bolted wooden construction of model A.

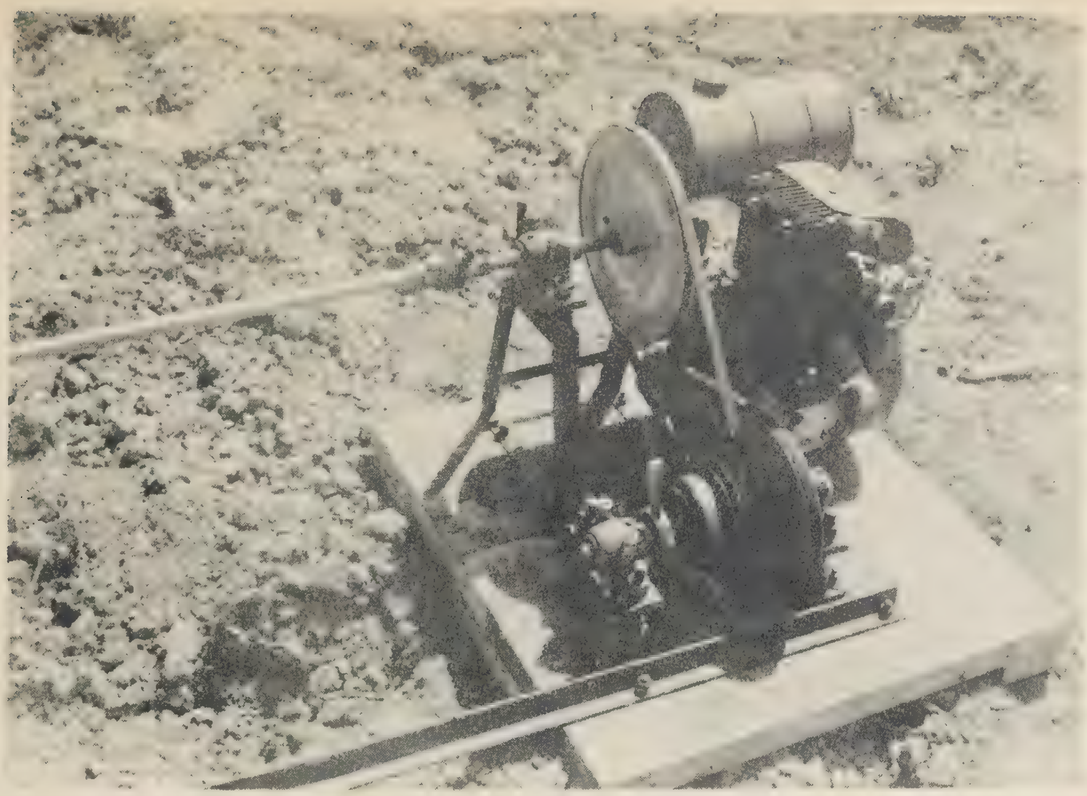

Figure 3.—Motor and clutch assembly of Corvallis trap, model A. Note connecting rod with flexible connection, extending from drive pulley to net drive shaft. The bendix spring shown in this figure is not especially durable and was later replaced by a tubular iron sleeve which was united to each shaft by a pin. The clutch is a manufactured unit used in small machine and woodworking shops. The motor is a 1-horsepower, air-cooled gasoline engine. (Photograph by K. W. Gray.)

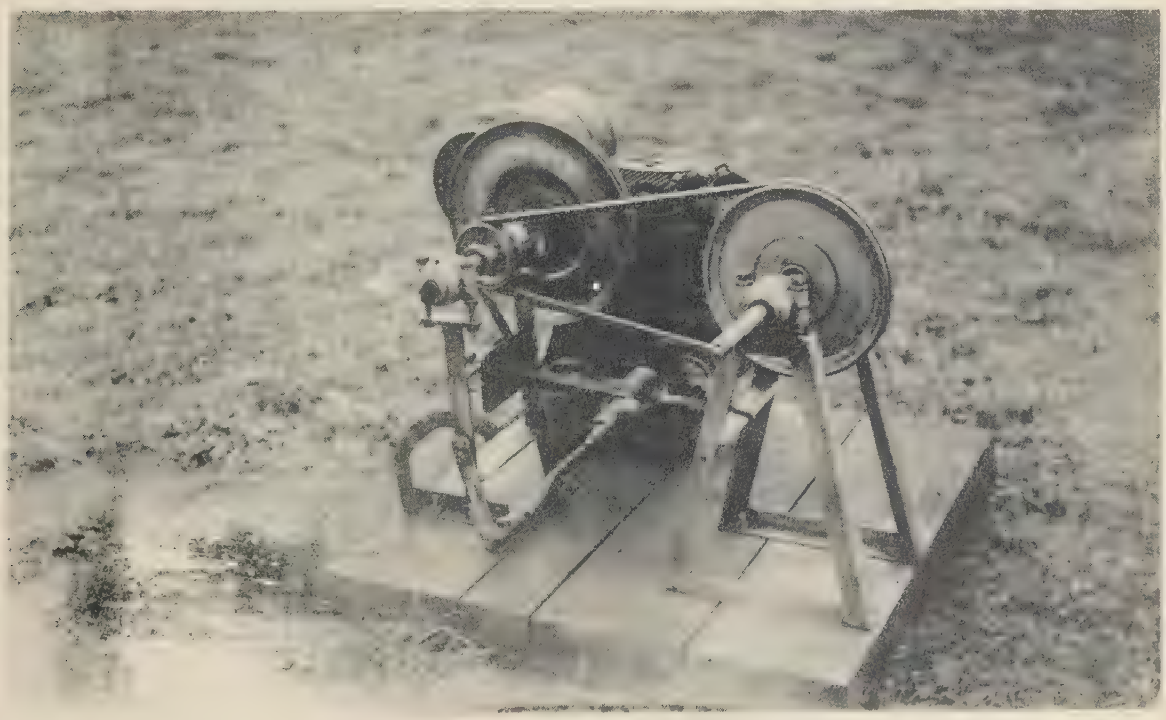

Figure 4.—Motor and clutch assembly used on Corvallis trap, model B. The trap is started or stopped by tightening or loosening the belt by means of the specially mounted automobile jack, which tilts the countershaft. This is as effective as the clutch arrangement shown in figure 3, but causes greater wear on the belt.

Figure 5.--Model of the trap used to study height of insect flight. The top net is 32 feet from the ground. (Photograph by Dwight F. Barnes.)

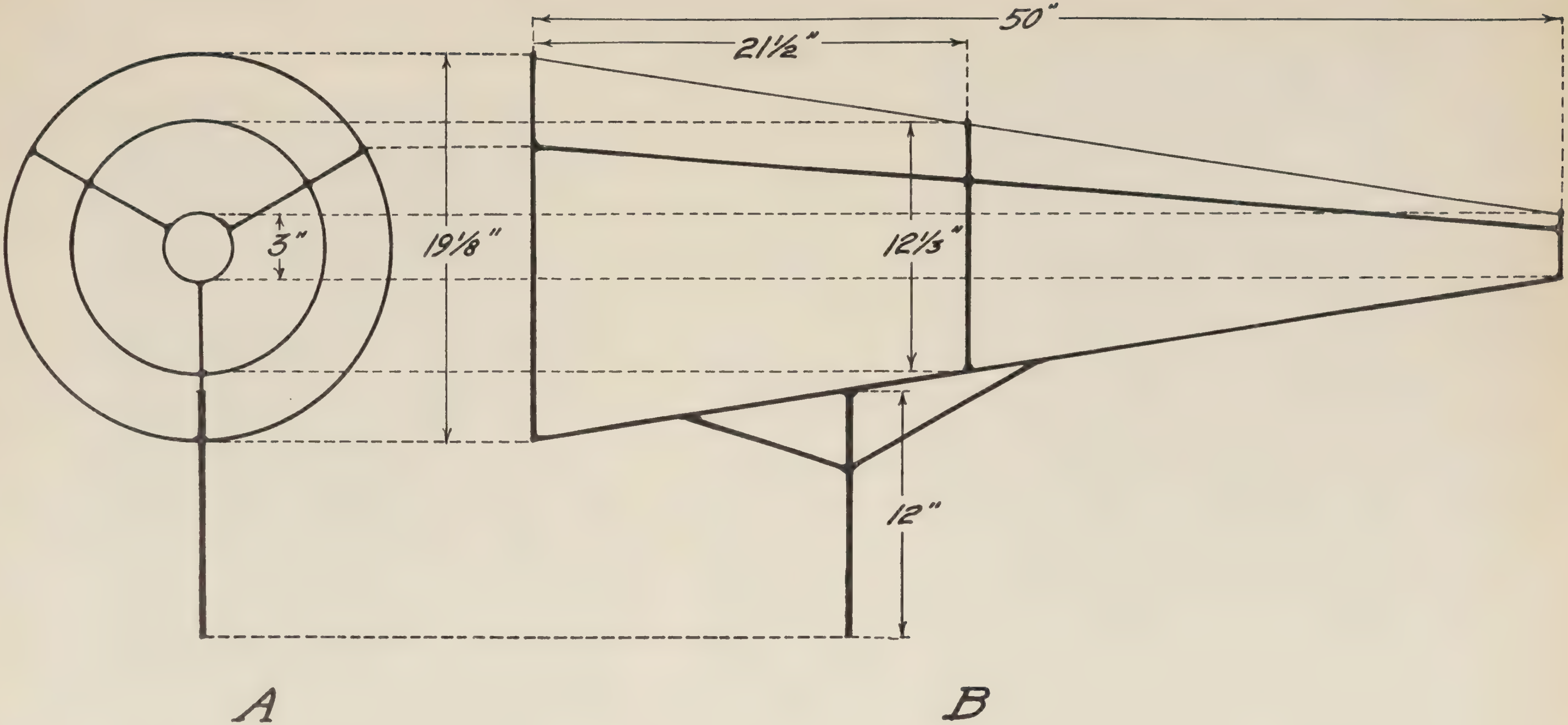

Figure 6.--Diagram showing the dimensions and construction of the collecting net. The framework is of 1/4-inch iron rod and welded throughout, except for the 12-inch supporting arm, which is of 1/2-inch rod or pipe. A, Front view. B, Side view. The net covering (not shown) is of 16-mesh screen wire with all seams soldered.

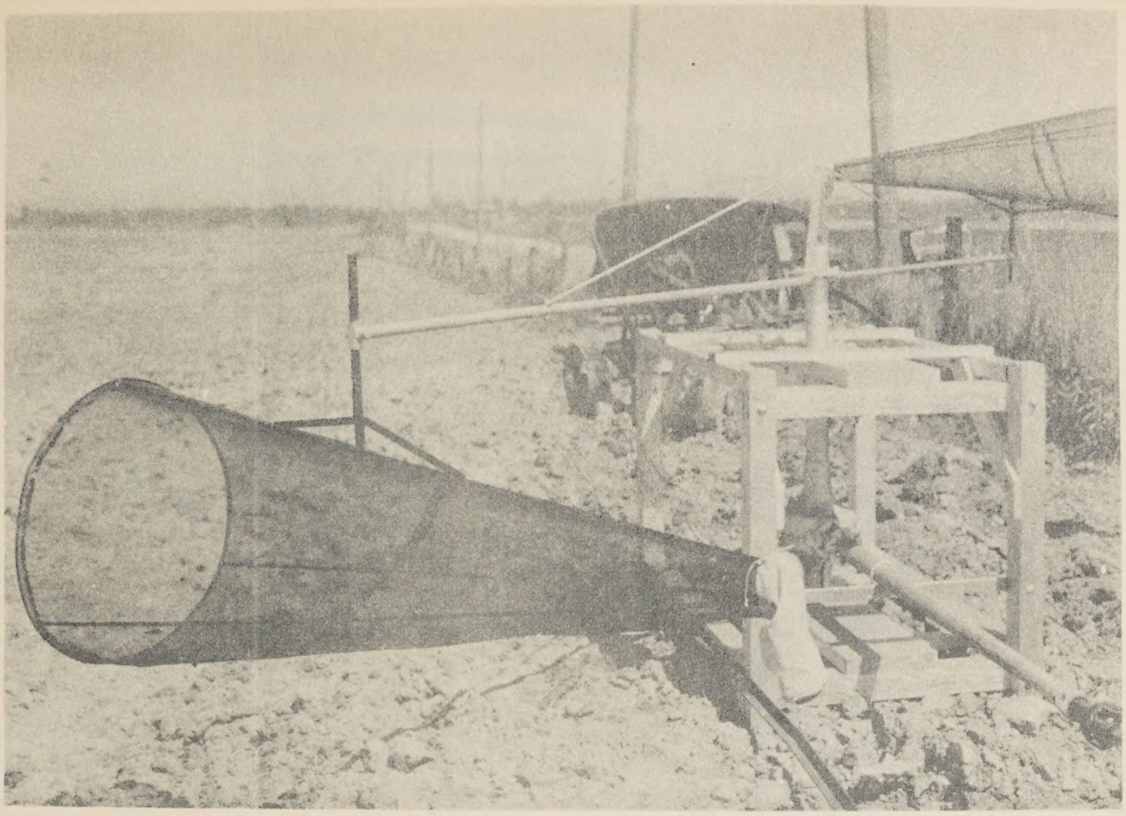

Figure 7.--Mounting of the collecting net. The net is fastened to the net arm by an iron rod, which runs in a vertical slot at the tip of the net arm and is adjustable as to height within certain limits. It is held in place by a set screw. A wire brace extends from the large and small ends of the net to the net arm at the point of the brace attachment to prevent the net being displaced from its proper position by centrifugal force. (Photograph by K. W. Gray.)

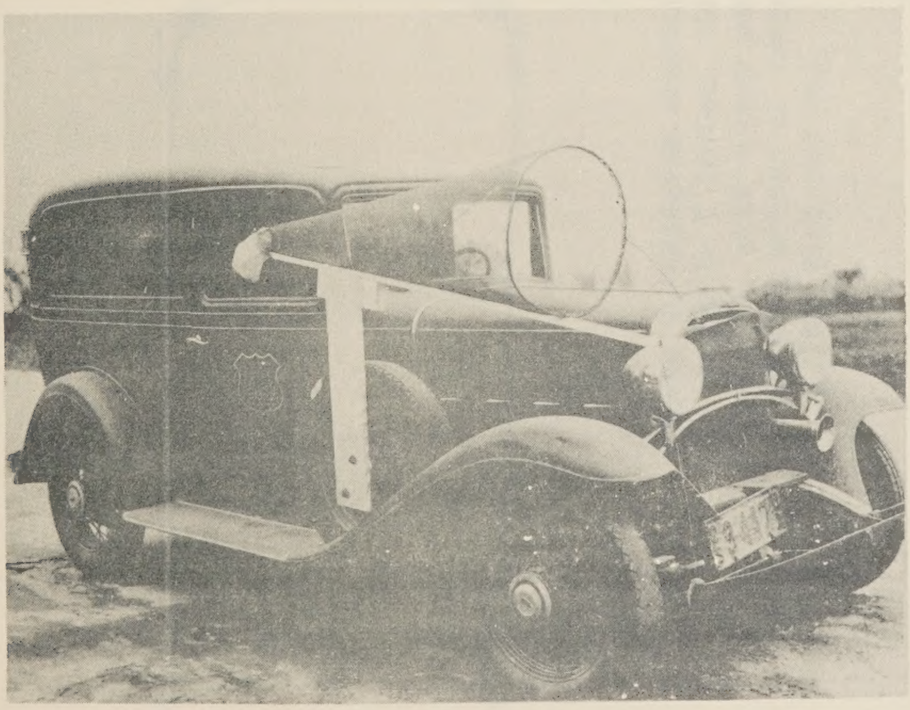

Figure 8.--Collecting net, of the type used on the rotary trap, mounted on an automobile for use in sampling aerial populations over extended areas.

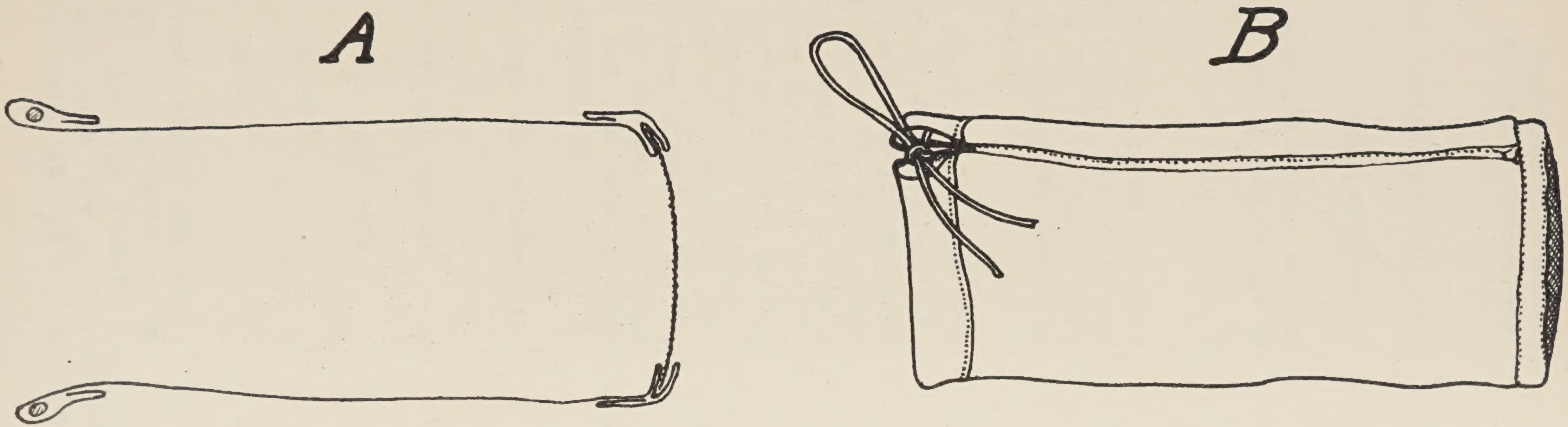

Figure 9.—Diagram showing construction of the collecting bag. The length is 7 inches, the diameter 3-1/4 inches. The material is muslin, with copper gauze bottom. A, Diagrammatic cross section showing method of sewing in the drawstring and the screen bottom. B, The finished bag.